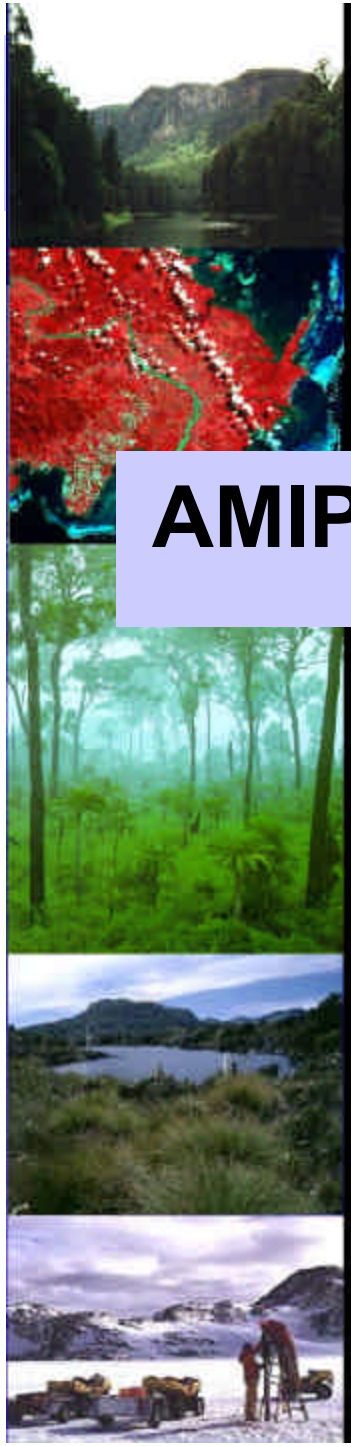

AMIP II's Land-surface Energy Budgets

A. Henderson-Sellers, P. Irannejad, K. McGuffie, S. Sharmeen, T. Phillips, H. Zhang and A. Pitman

UCRL-PRES-151723

AMIP II DSP 12

Land-surface Energy Budgets

PILPS

- Investigating the partitioning of land-surface energy budgets of 20 AMIP II models reveals:
- Two clear clusters (SiBlings & buckets)
- SiBlings predict latent heat best
- Intermediate climates hardest for all models
- In wet climates:
  - models & reanalyses overestimate latent heat
  - cf. reanals models underest. LH & overest. SH
- LH spatio-temporal correlations best in wet climates and worst in arid ones
- Improvements are possible with learning

AMIP II DSP 12

From AMIP I to AMIP II

- What we learnt from AMIP I
  - energy conservation was a problem
  - soil water stores evolved during simulations
  - no one LSS does best always
  - ensemble of all LSSs performs better than individuals
- AMIP II process improved
  - spin-up to gain equilibrium
  - improved reporting & of more fields
  - more LSSs participating - wider variety of capability
- Current status
  - 20 AMIP II AGCMs' simulations released for analysis
  - World leader investigating LS results and another AGCM LS reports are suspect as a result of DSP12

AMIP II DSP 12

Participating Models & LSSs

- Models are: CCMA, CCSR, CNRM, COLA, DNM, ECMWF, GISS, GLA, JMA, MGO, MPI, MRI, NCAR, NCEP, PNNL, SUNYA, UGAMP, UIUC, UKMO, YONU (A-T but not this order)
- LSSs include: buckets (Manabe 1969), SVATs (e.g. BATS, SiB), newer LSSs (e.g. UKMO)
- Some overlaps among models & LSSs:
  - E & M same LSS & host AGCM; different resolution
  - F & N same LSS but different version of host model
  - I & J same LSS & host but different AGCM vert. res.
  - L & Q same LSS but different AGCMs

PILPS

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Investigation of Energy Partition

- Search for validation data
  - observations: none for global fields of interest eg LH
  - VIC: LSS forced off-line & calibrated on world rivers
  - reanalyses: ECMWF; NCEP-DOE; NCEP-NCAR
- Homogenise for analysis
  - all models' and reanalyses' data are analysed at T63
- Sort by de Martonne climate types

  Index = Precip / (Temp + 10)
  - Precip is mean annual precipitation (mm); Temp is mean air temperature in ^{o}C; 7 types + Polar when Temp < -5 ^{o}C
  - Data: Precip from CMAP; Temp ensemble reanals
- Review basic conservation

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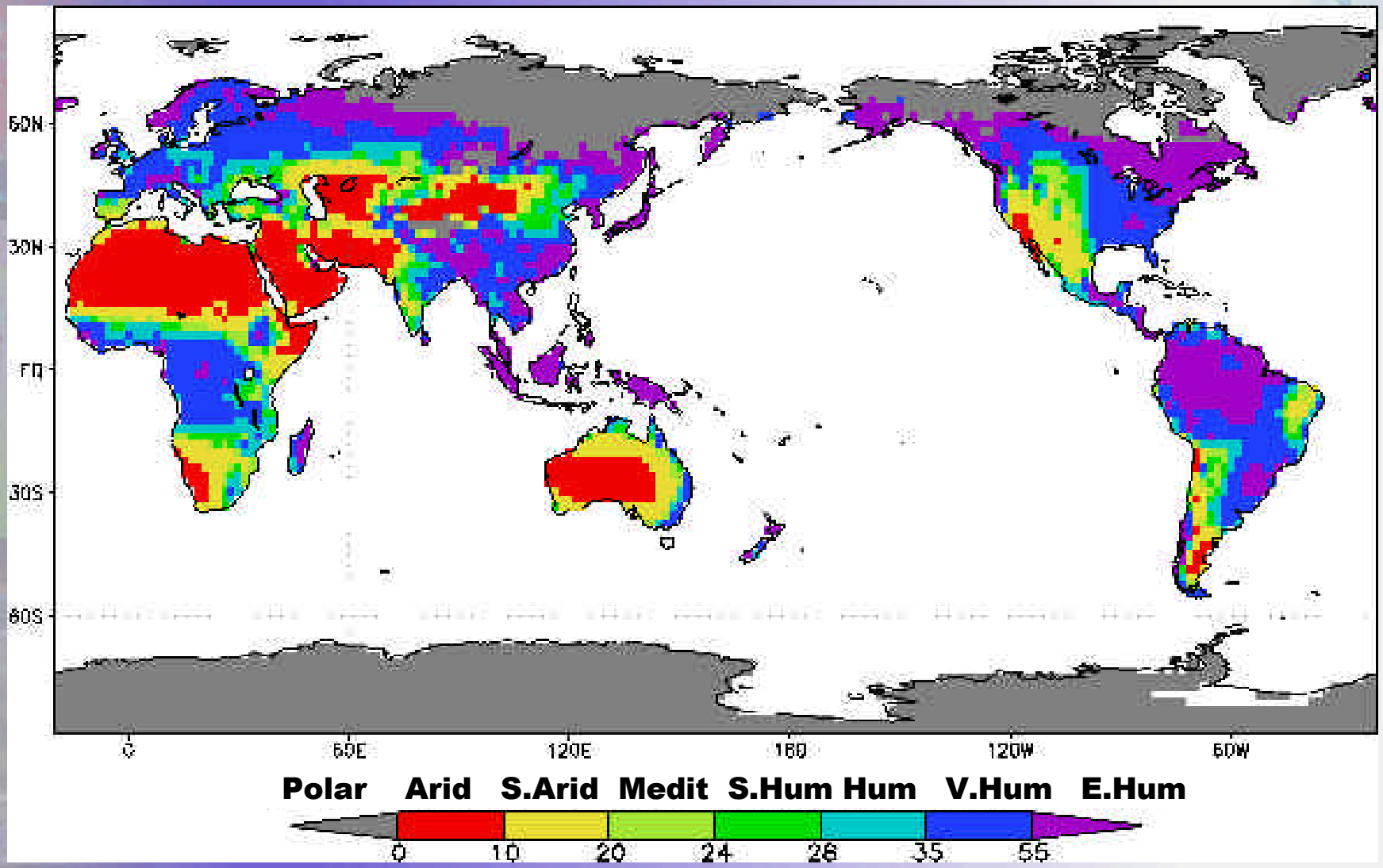
De Martonne Climates



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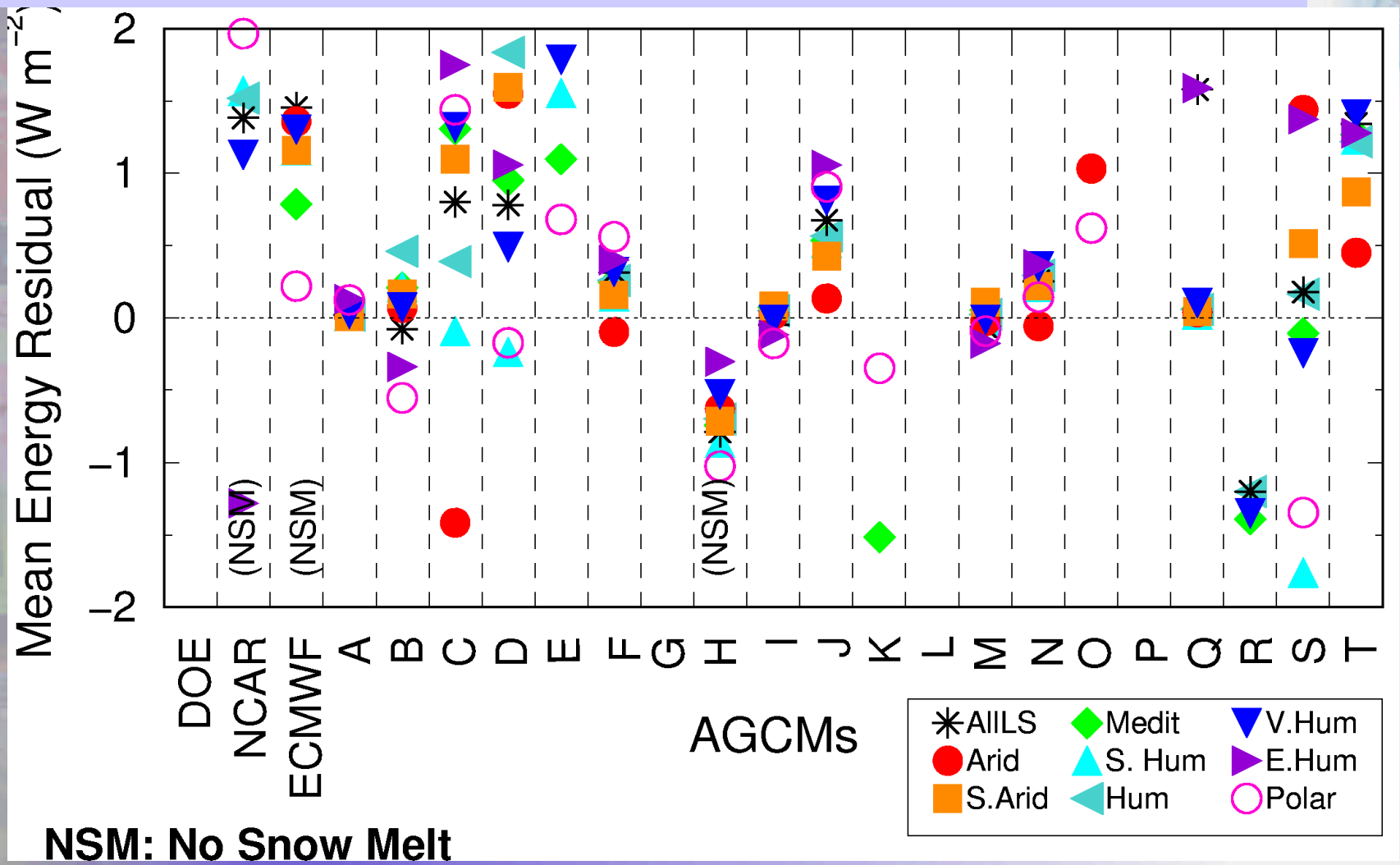
Land-surface Energy Budgets



NSM: No Snow Melt

- **Most models' SEB within ± 2 W m^{-2}**

PILPS

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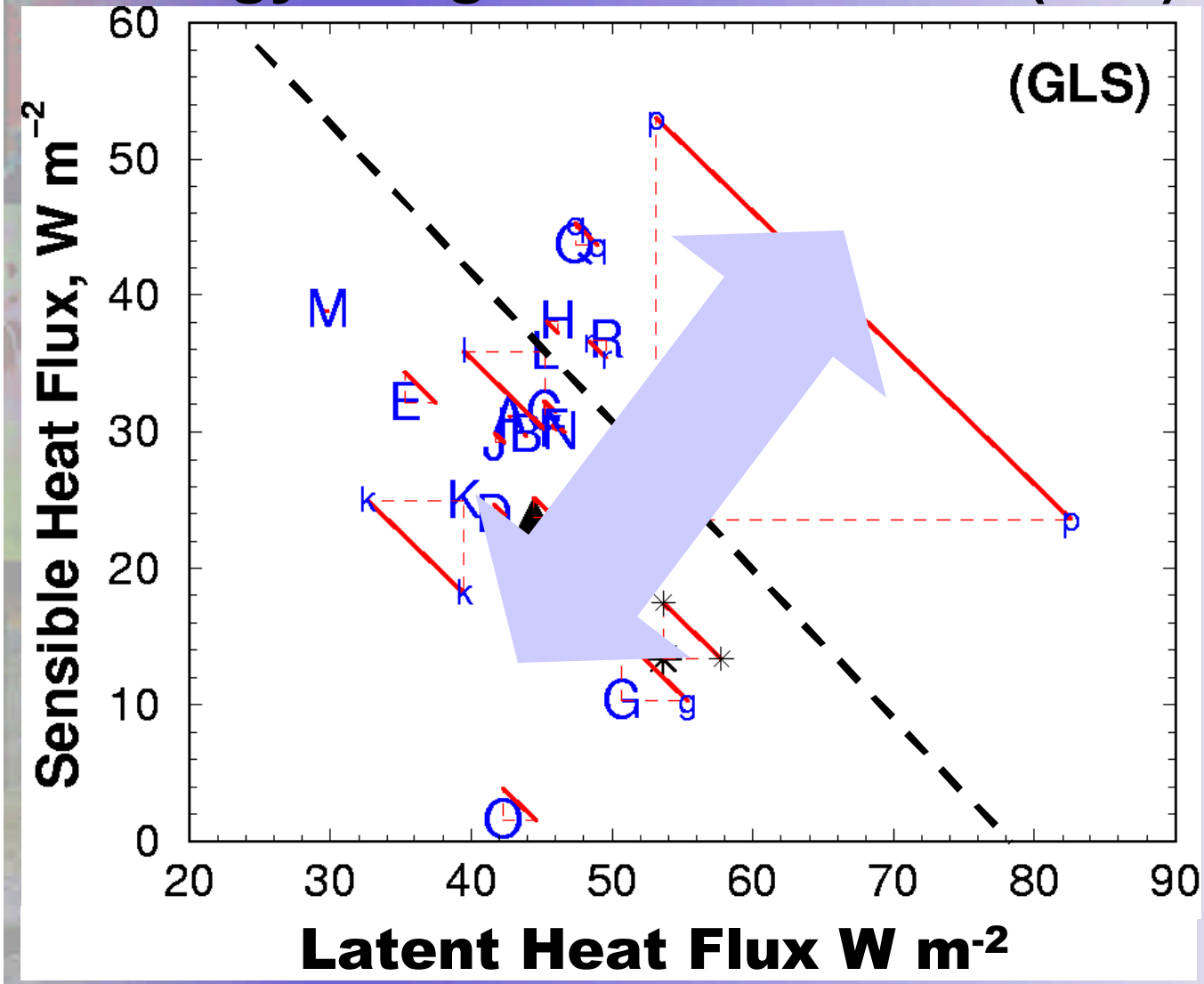
Land-surface Energy Partition

- **Energy budgets of 20 models (A-T) & 3 reanalyses**



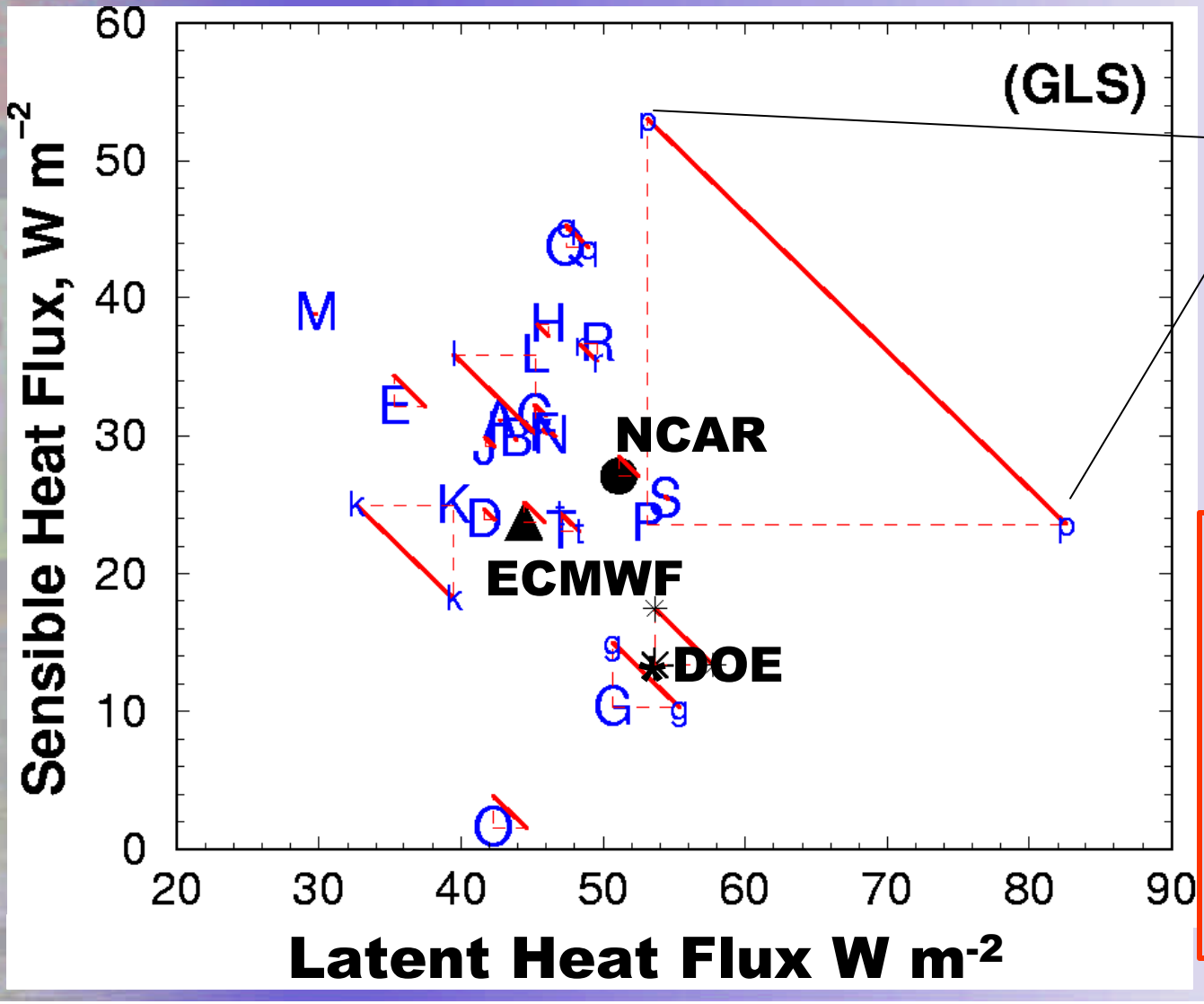
Scatter along diagonal shows differences in partitioning surface available energy

Scatter around diagonal is due to predictions of different values of surface available energy

AMIP II DSP 12

Land-surface Energy Partition

- **Energy budgets of all but 2 or 3 models ± 2 W m^{-2}**



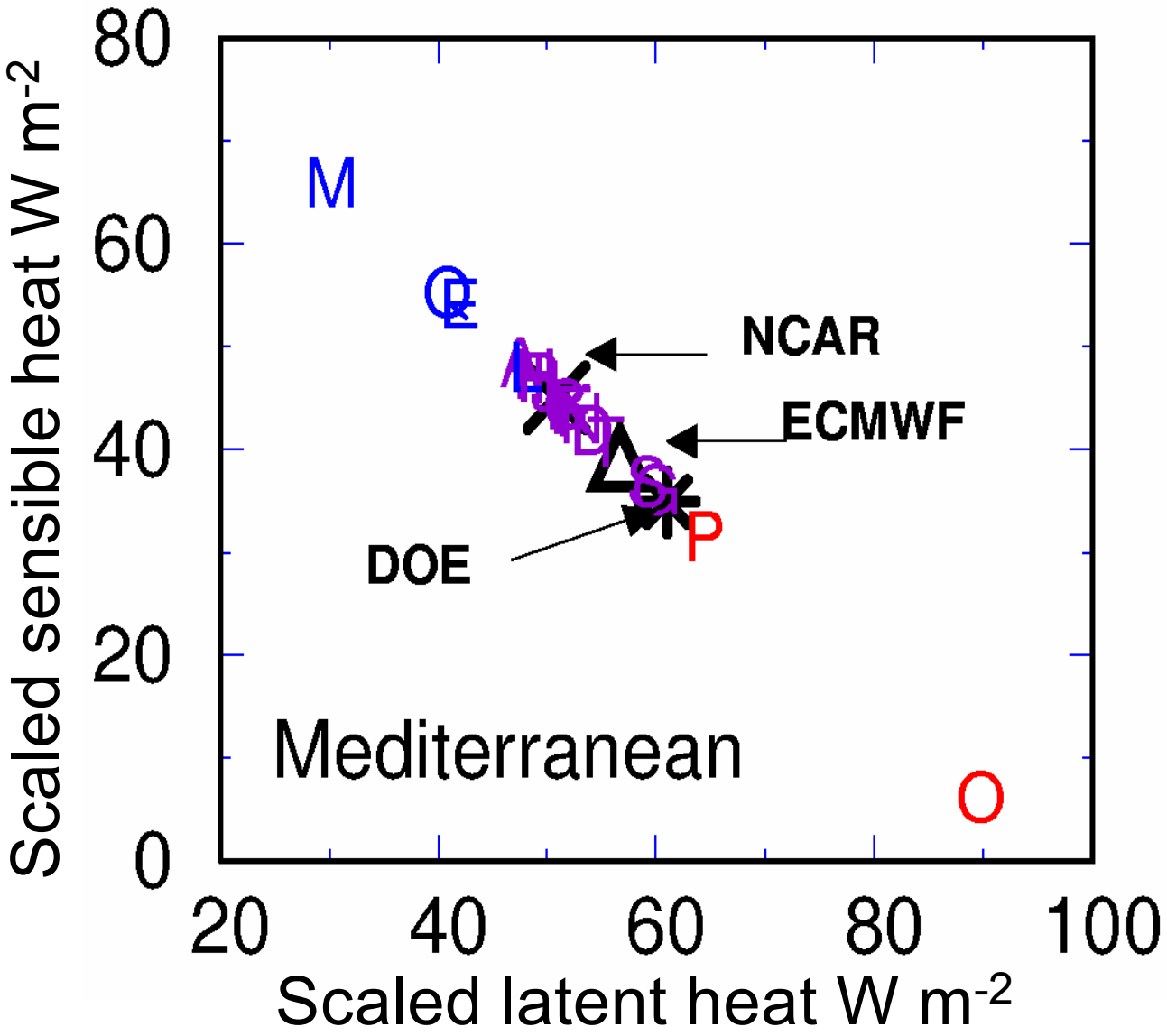
SEB not fully closed : assumes no net change in surface energy store.

AGCM P's downward longwave radiation is 30 W m^{-2} > AMIP average

AMIP II DSP 12

Normalised SEB Using Reanalyses

- SEB for each model normalised using the ensemble of the three re-analyses



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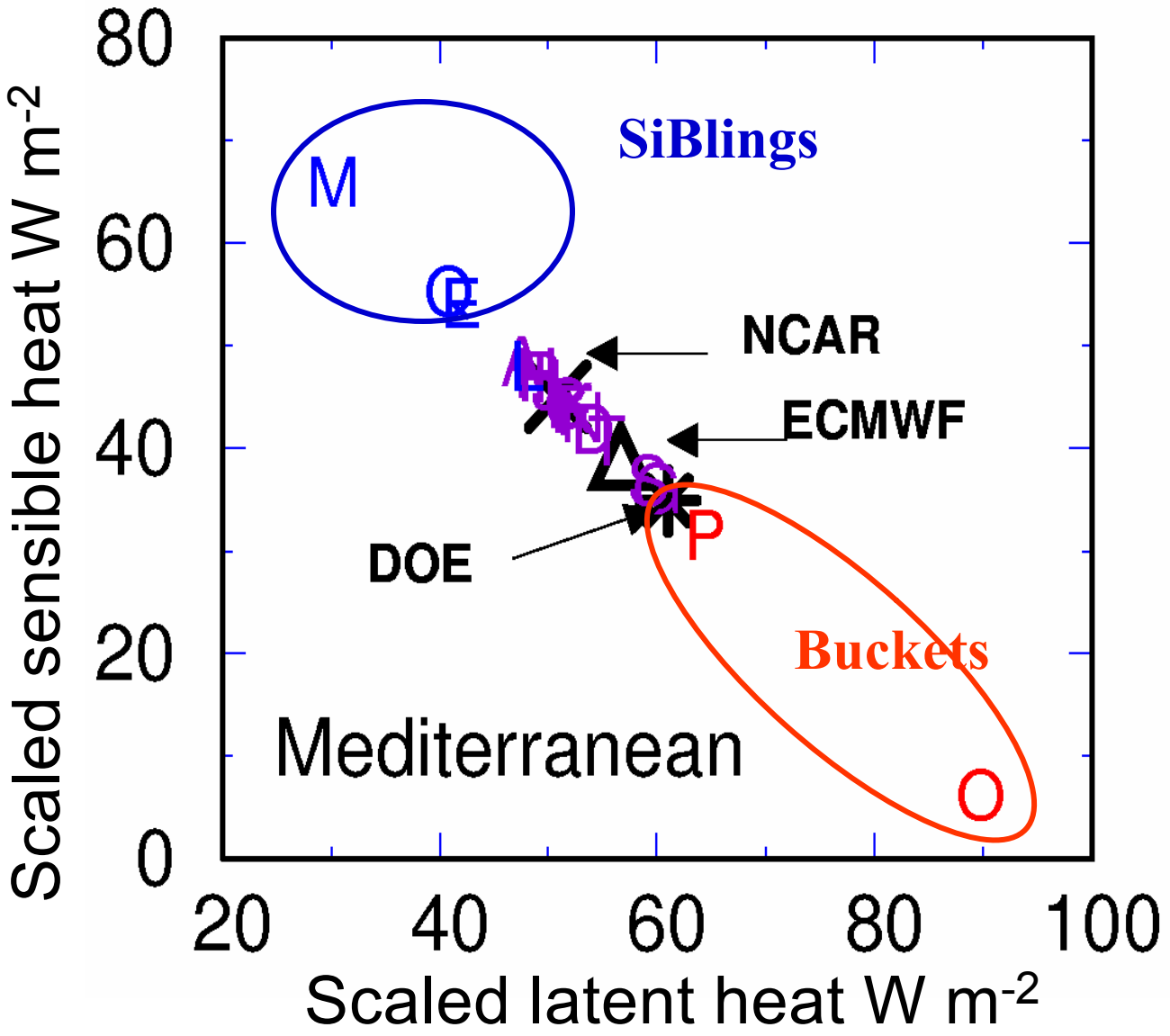
Clusters Begin to Emerge

- M, Q, E & L are all SiB or SSiB called the SiBlings
- P & O are both Manabe 1969 'buckets'



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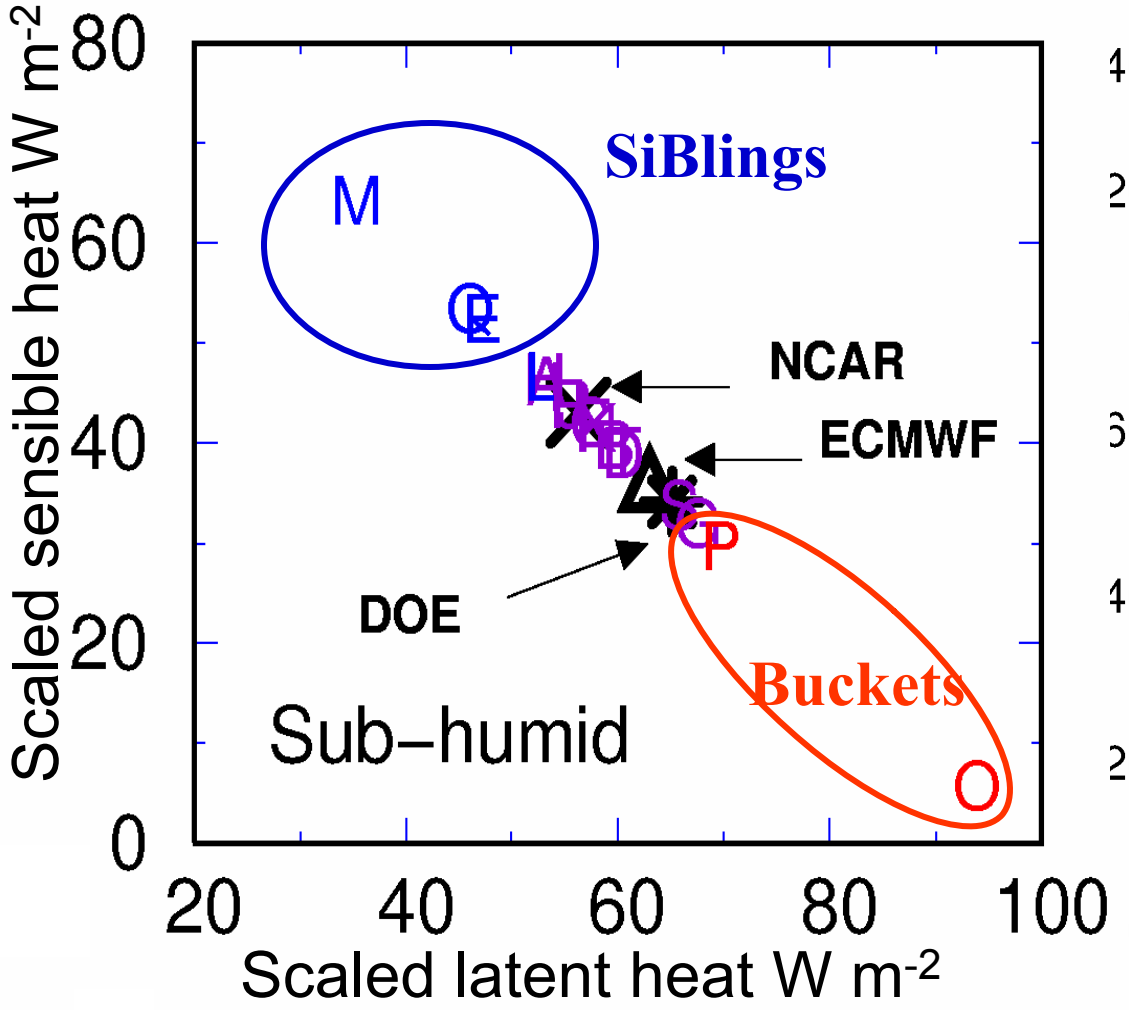
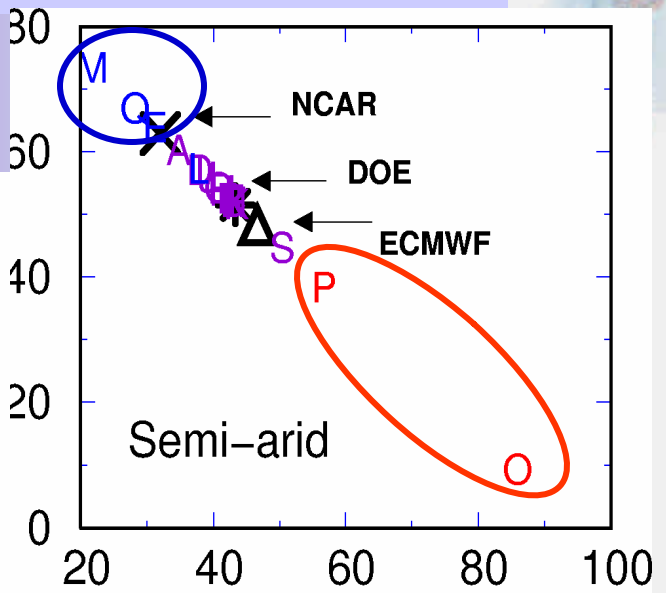
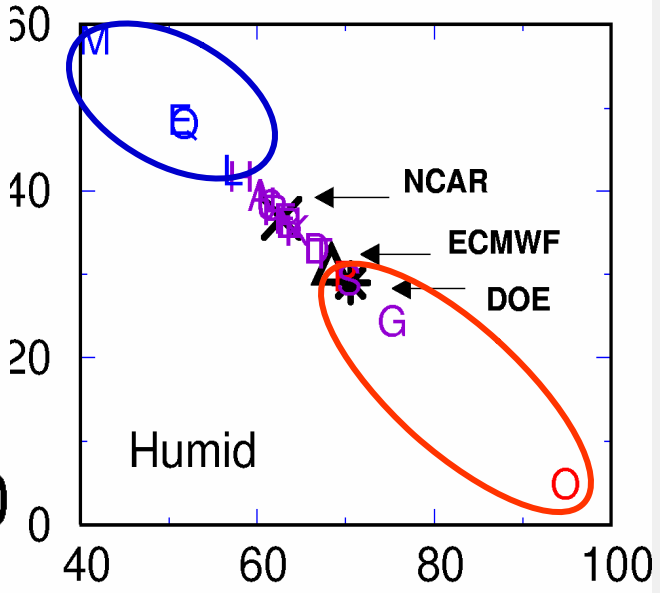
LSS Clusters in All Climates

- **SiBlings & buckets**







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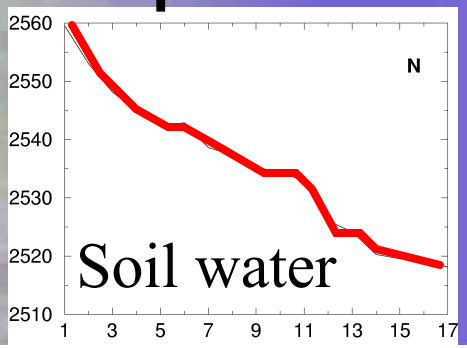
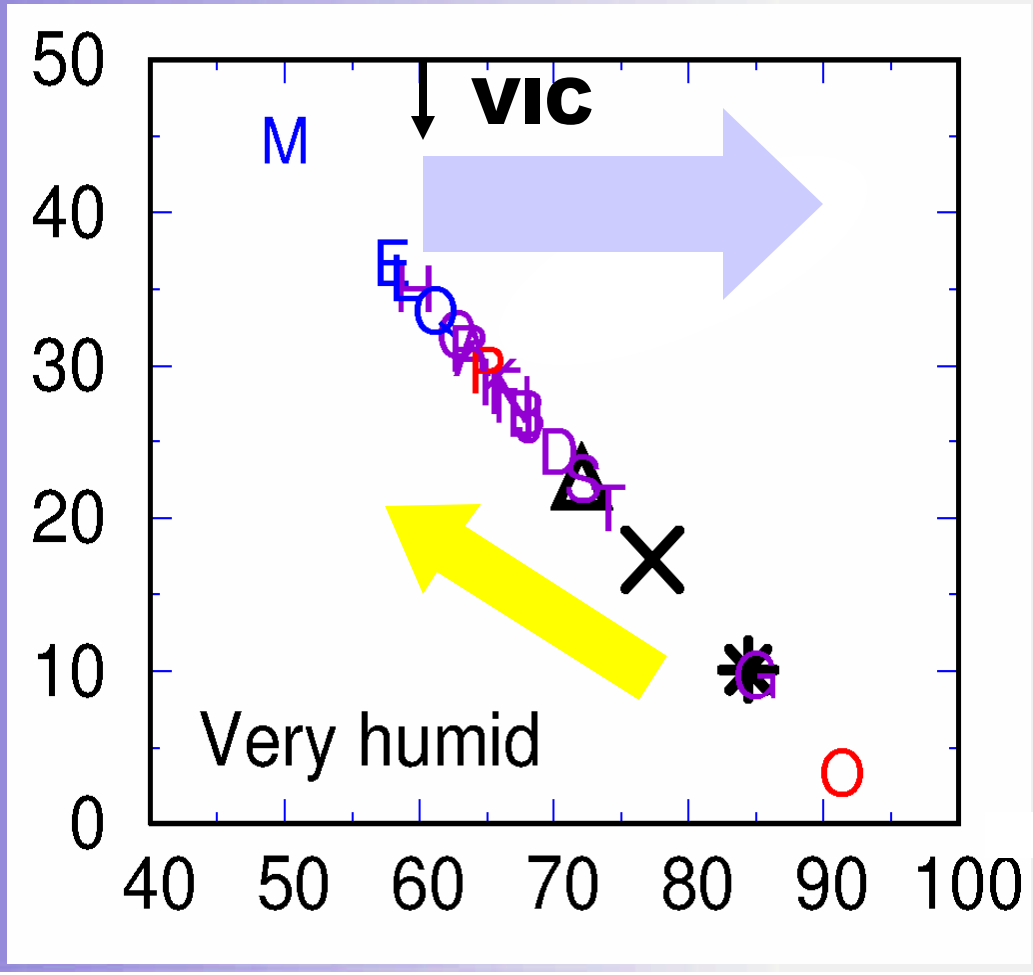
Humid Climates a Challenge

- **In wet climates (Humid, Very & Extremely Humid)**
  - **models & reanalyses overestimate latent heat compared to VIC**
  - **compared to reanalyses, models under-estimate LH and over-estimate SH**
  - **some spin-up problems still**





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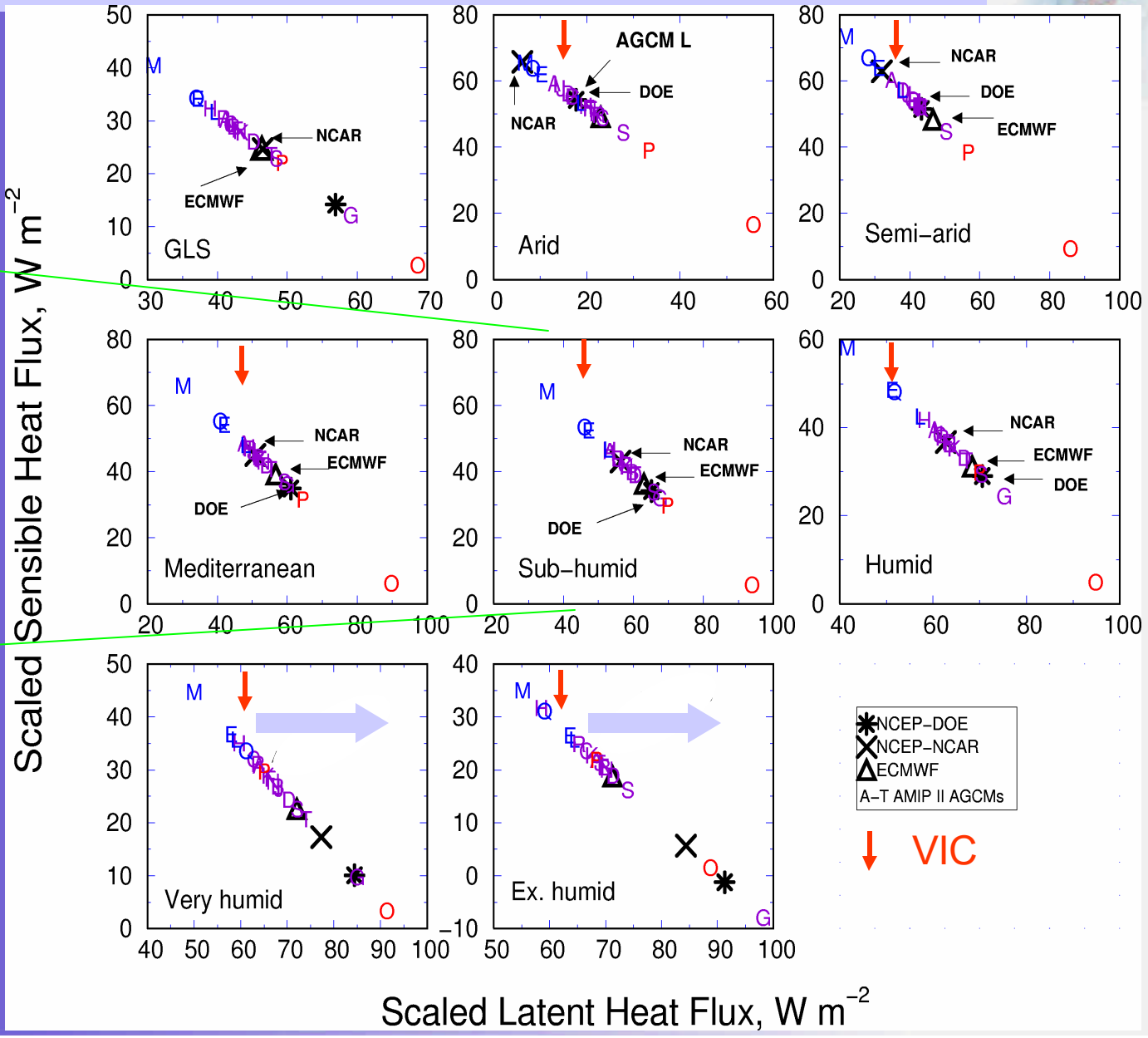
Evaluating Performance

SiBlings best cf. VIC

Intermediate climates hardest because reanalyses agree best

LH too large in wet climates cf. VIC



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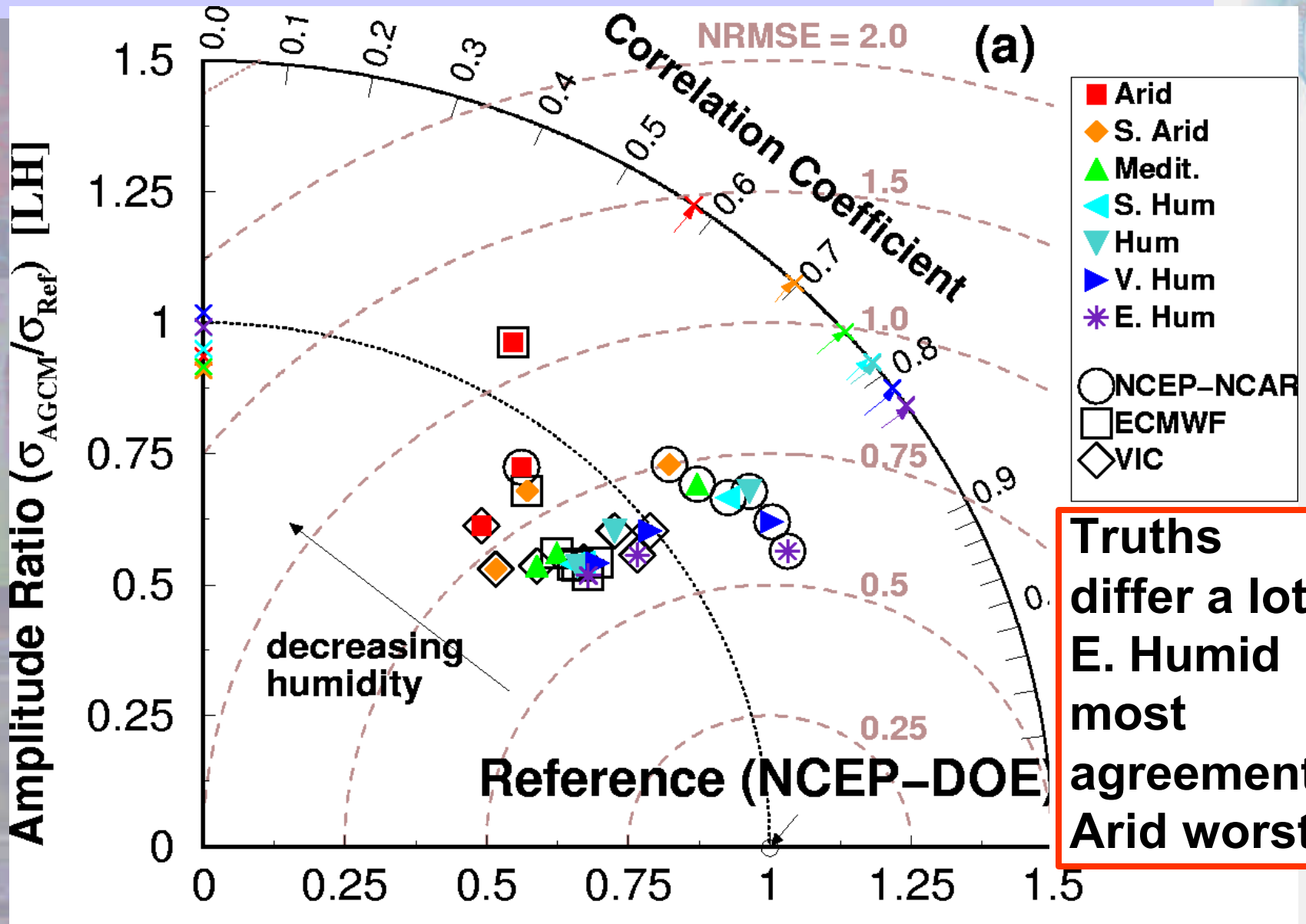
Spatio-temporal Correlation

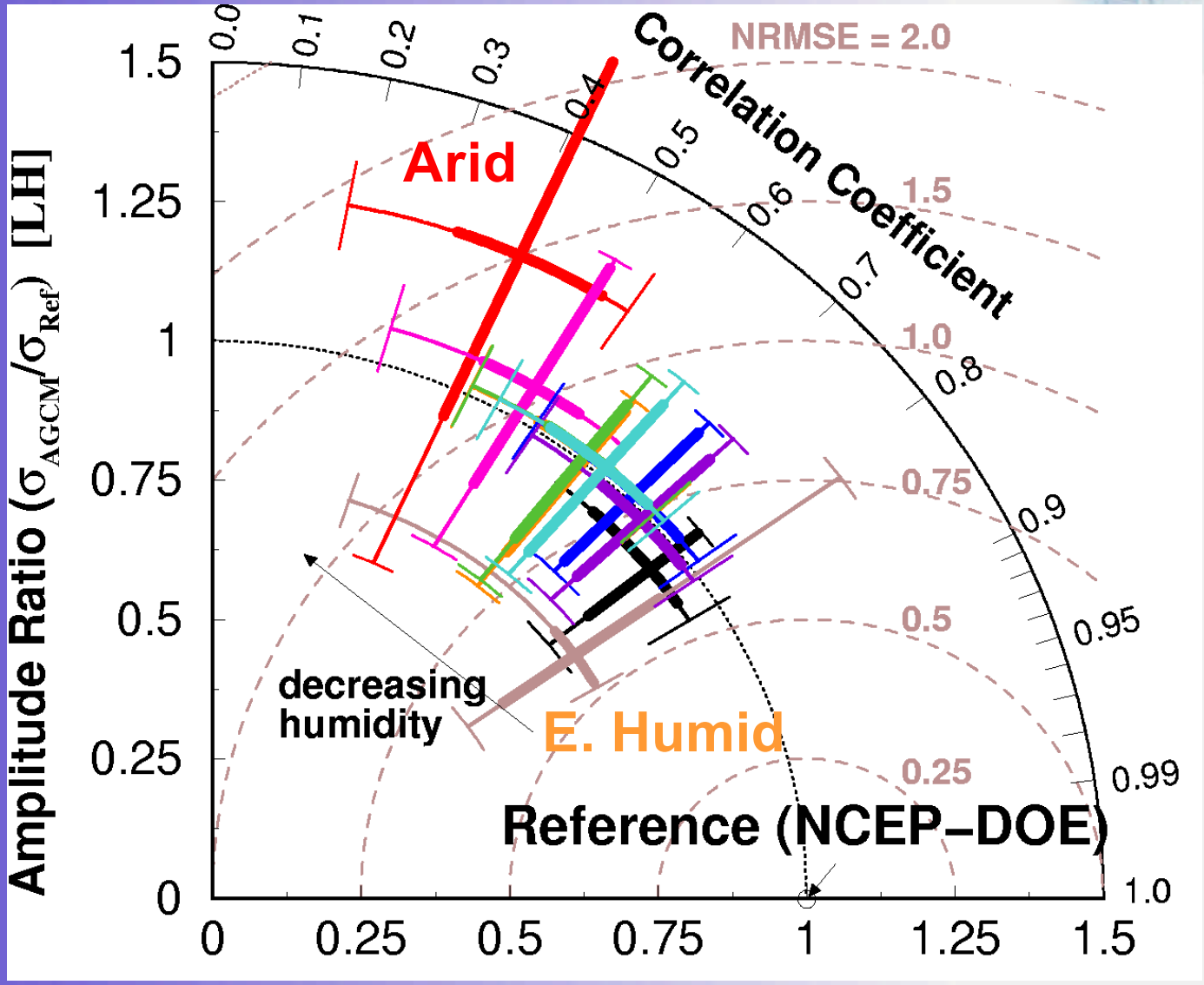


Truths differ a lot; E. Humid most agreement Arid worst

AMIP II DSP 12

Box-Whisker S-T Correlation

Box-whisker plots of models A to T show: latent heat correlation best in humid climates, worst in arid



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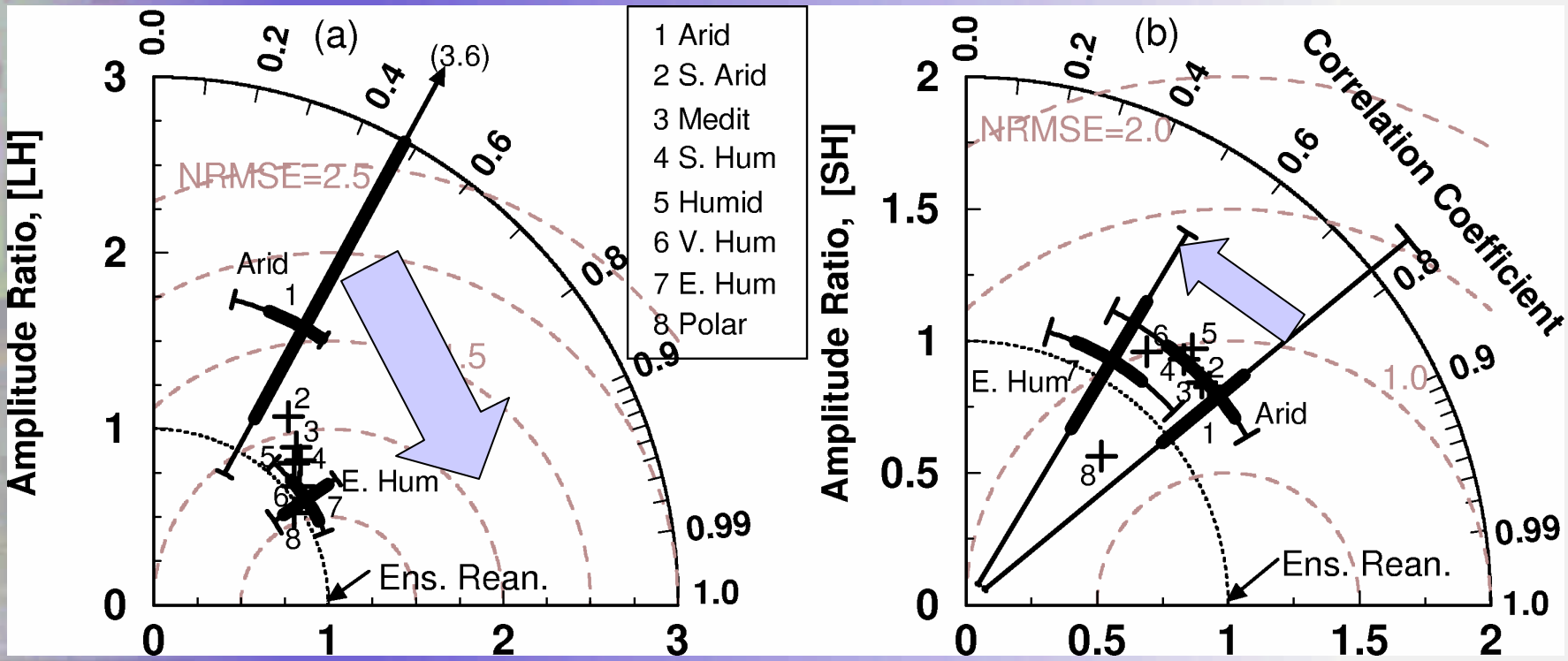
Spatio-temporal Analysis

- LH migrates towards ensemble ‘target’ from Arid (worst) to E. Humid (best)
- SH opposite but ranges diminish less



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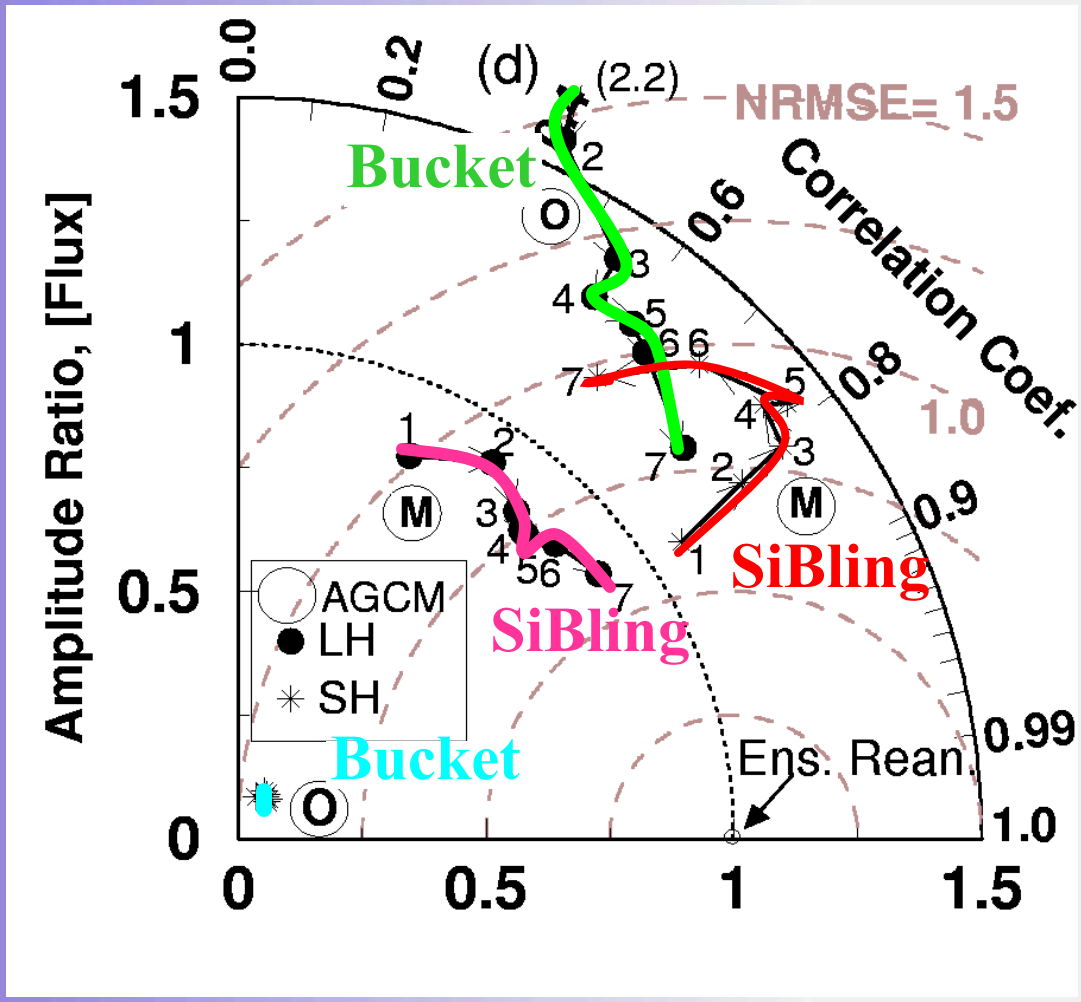
Spatio-temporal Correlation

- Climate trajectories differ for SiBlings & buckets
- LH improves from Arid (worst) to E. Humid (best)
- SH flows the other way
- Bucket (O) SH v. small & low variability



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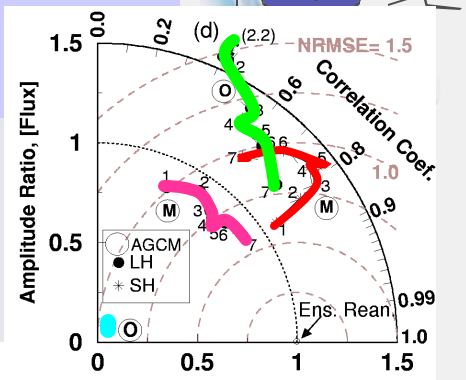
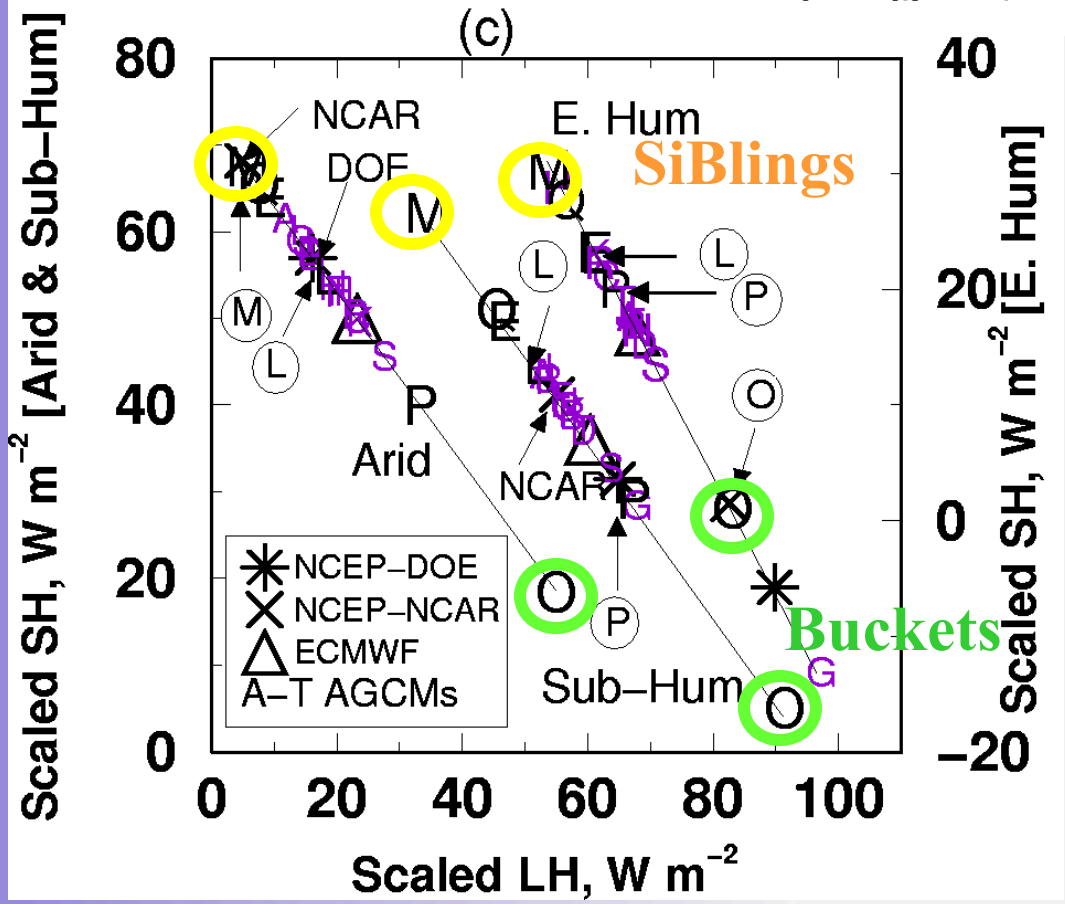
Overview & Exciting Results

- Two clusters (SiBlings & buckets)
- Different trajectories in S-T space
- SiBlings best LH
- Intermediate climates hardest
- Humid climates overestimate LH
- Models predict lower LH than reanalyses
- S-T correlation best for wet





AMIP II DSP 12

AMIP II Land-surfaces: Summary

- Land-surface energy budgets of 20 AMIP II models are overall better than those in AMIP I
  - all but three 'reasonable' energy residuals $\leq$ 2 W m^{-2}
  - for 11 the sum of fluxes lies within reanalyses
- 'Truth' for validation is still a problem
  - reanalyses disagree & differ from VIC (validated)
  - models near DOE (arid), NCAR(inter) & ECMWF(wet)
- SiBlings (a group) predict latent heat flux best
- Much more still to do
  - Intermediate climates hardest for models
  - For wet (humid) climates (spatio-temp. correlation is best)
    - models & reanalyses overestimate latent heat
    - compared to reanals, models underest LH & overest SH

AMIP II DSP 12

Where to from Here?

- Land-surface predictions *do* matter
  - agriculture, water resources, community comfort
- Good news is that community overall is improving predictions at the land surface
  - AMIP II has better LS skill than AMIP I
- Many schemes now get aspects of SEB right
- Buckets are too poor to be useful
- Complex LSS - such as SiB - can do very well
- Improvements can come from detailed analyses such as these & learning application
- AMIP III (!!) will have GREAT land-surface skill

PILPS

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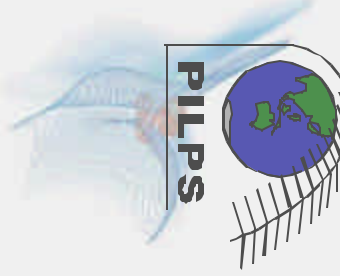

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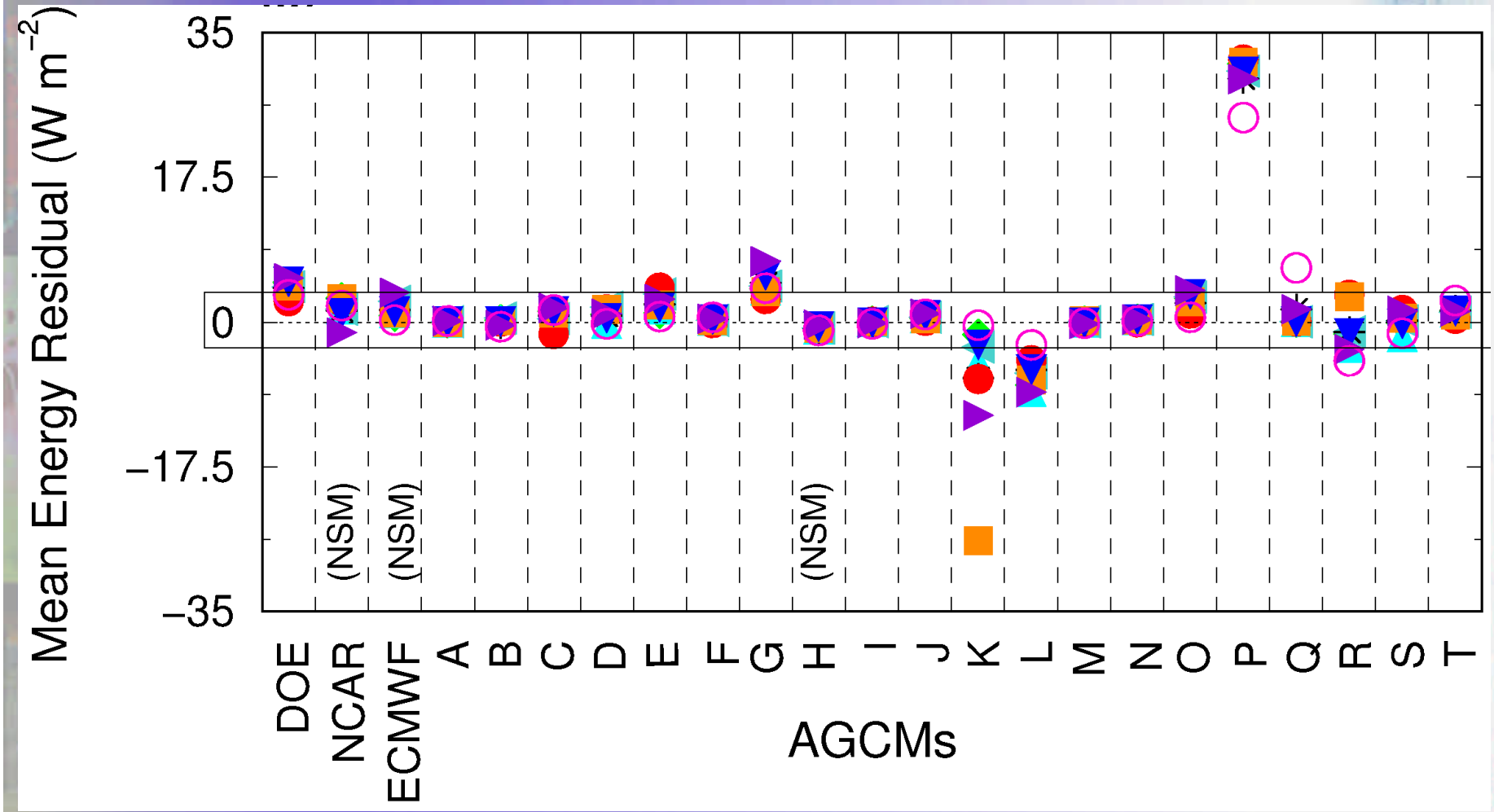
Land-surface Energy Budgets



- **A few models have problems e.g. P & K ?and G**

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UCRL-MI-116408 | Monday, February 26, 2001